PIGEON LAKE REGULATION FEASIBILITY STUDY

SUMMARY REPORT

Alberta
ENVIRONMENT
PLANNING DIVISION

PIGEON LAKE REGULATION

FEASIBILITY STUDY

SUMMARY REPORT

JULY, 1982

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Department of Environment staff wish to thank the members of the Pigeon Lake Level Study Committee for their assistance.

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INTRODUCTION

Pigeon Lake is in central Alberta, equidistant from Edmonton and Red Deer. The lake area is approximately 90.6 km^2, and the lake drains via Pigeon Lake Creek into the Battle River (Figure 1).

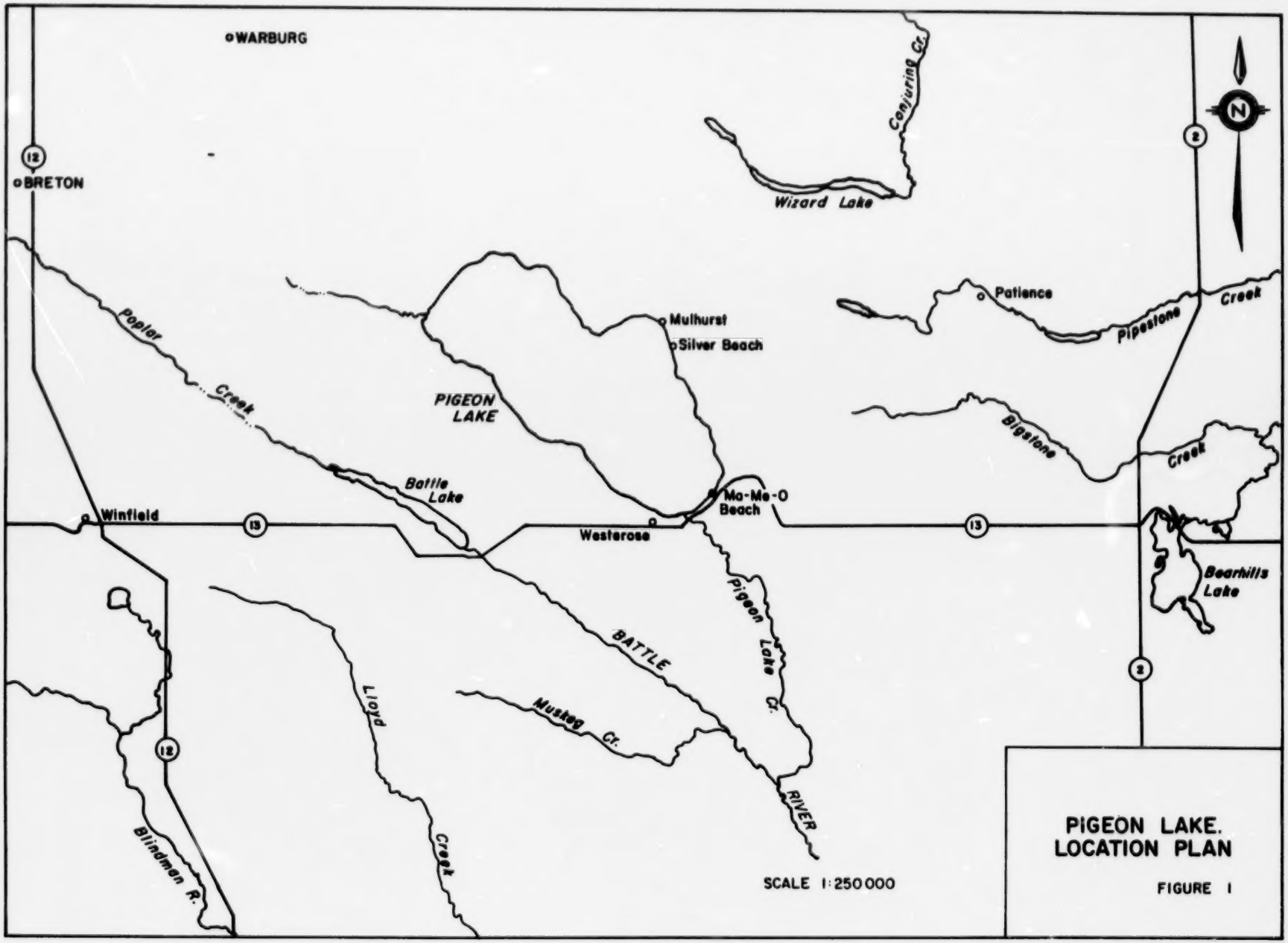
Agriculture is the main land use in the area. The shore of Pigeon Lake is intensively used for both public and private recreation. Approximately 60% of the shoreline is occupied by cottage development.

BACKGROUND

In 1914 the Federal Government built a dam on the Four Bands Reserve at the outlet of Pigeon Lake to Pigeon Lake Creek. The dam was rebuilt in 1939-40. The dam at the outlet of Pigeon Lake is an earthfilled wooden structure with two bays eight feet wide. These bays can be closed with stoplogs. The dam is showing signs of deterioration and will require replacement in the near future. The stated purpose of the dam was "to stop the flow of water through Pigeon Creek during late summer to prevent flooding of hay lands in that area".

The 1975 Pigeon Lake Study identified recreation as the prime use of Pigeon Lake. The study recommended that the lake be developed for recreation to its social and ecological capacity, to meet the rising demand for recreation and to relieve pressure on less suitable lakes. The lake level, at the time of the study, was 850.5 m and residents did not want the lake level reduced.

By 1980 lakeshore residents were concerned by high lake levels. In the fall of 1980 Alberta Environment cleaned the outlet in an attempt to reduce lake levels. This did not work because the actual lake level


WARBURG
BRETON
Conjuring Cr.
Wizard Lake
Patience
Pipestone Creek
Mulhurst
Silver Beach
Poplar Creek
PIGEON LAKE
Battle Lake
Winfield
Ma-Me-O Beach
Westerose
Bigstone Creek
Bearhills Lake
Pigeon Lake Cr.
BATTLE
Lloyd Creek
Mustag Cr.
RIVER
Blindmen R.
N
SCALE 1:250000
PIGEON LAKE.
LOCATION PLAN
FIGURE 1

control was the restricted creek channel. Instead, downstream flooding was aggravated because the creek channel was unable to handle the additional flow. Maintenance work on the creek and dam carried out in 1981 did permit additional flow from the lake without downstream flooding problems and the lake level fell from 850.6 m to 850.2 m by December, 1981.

STUDY OBJECTIVES

It was determined that a study of Pigeon Lake and Pigeon Lake Creek concerns was necessary to supplement the short term measures mentioned above. The objective of this study was to develop a long term solution to cottagers' concerns regarding high lake levels without creating more problems on Pigeon Lake Creek. Therefore the effect on the creek of any changes to lake levels had to be reviewed.

The study terms of reference were:

1. Examine the technical, environmental, and economic feasibility of alternative solutions to high water levels on Pigeon Lake and flooding along Pigeon Lake Creek.
2. Identify the preferred alternative.
3. Assess the distribution of benefits, and cost-sharing alternatives.
4. Develop an operating schedule for any structural components of the recommended alternative.

STUDY ORGANIZATION

At the outset the only identified concern of cottagers was that lake levels were too high at 850.6 m in 1980. In terms of developing

a study method, two of the major objectives were to identify the scale, type and distribution of problems and to determine the lake level the residents preferred. The effects of lake level alteration on the creek and on the natural environment of the lake were not known, and the control over lake levels that could be exercised and the cost had to be determined.

Three component studies were undertaken to fulfill the terms of reference:

1. Hydrotechnical
2. Environmental
3. Socio-Economic and Public Participation

Possible lake level control methods and their costs were determined. The suitability of control measures was assessed on the bases of environmental implications, downstream effects, popular support for the solution, cost and effectiveness. This report deals separately with each of the component studies.

Metric units are used throughout this report. They can be readily converted to Imperial units by dividing by 0.3048. Thus a lake level of 849.33 m is coverted to feet as follows:

$$849.3 \div 0.3048 = 2786.5 \text{ feet}$$

HYDROTECHNICAL ANALYSIS

PURPOSE

The purpose of the hydrotechnical study was to gain an understanding of the lake and the extent to which lake levels could be controlled. The impact on Pigeon Lake Creek of controlling lake levels was assessed and alternative control measures and their costs were determined.

METHODOLOGY

A water balance model of the lake was developed to simulate the historical pattern of changing lake levels. This model was then used to determine the effect on lake levels of various volumes of outflow.

Pigeon Lake Creek was surveyed following the 1981 maintenance work. This was done so that the channel capacity could be determined and compared with the various lake outflows.

BACKGROUND

Pigeon Lake is subject to cyclic variations in water levels. There have been times when the lake was below the level of the dam and no outflow occurred. The lowest recorded level was 849.33 m in 1968. The highest recorded level was 850.71 m in 1948. During low cycles (e.g. 1961-1972) the Department of Environment is asked to raise the water levels because of mudflats. During high cycles, requests to lower the lake level are made.

There are limits to the degree of control that can be exercised on the lake. Ideally a regulated lake should be held close to a chosen lake level. To do this, runoff into the lake must always equal or

exceed losses from the lake. The outlet from the lake must also be large enough to remove excess runoff without increasing the lake level. These conditions are seldom, if ever, met.

In the case of Pigeon Lake the size of the lake makes controlling lake levels very difficult. Evaporation losses will exceed inflow in dry years, and in wet years high outflows generated by spring runoff or summer storms will occur. Regulation of the lake will result in greater variations in flows downstream, hence the effects on the creek must be considered.

PIGEON LAKE LEVEL ALTERNATIVES

Northwest Hydraulic Consultants developed a water balance model of Pigeon Lake based on data for the 16 year period from 1965 to 1980. The model simulates lake level changes resulting from changes in natural phenomena e.g. rainfall, evaporation. The simulated annual fluctuation pattern compares reasonably well with the actual historic pattern. Plate 1 (Appendix A) shows the measured and simulated historic levels. Variations are the result of the simplifying procedures used in the model. Details of the simulation can be obtained from the main report.

During the 16 year study period the level of the lake varied 1.22 m from 850.55 m to 849.33 m.

From 1965 to 1972 the level was rarely above the sill level of the structure, so there was no outflow from the lake. Under such conditions lake levels cannot be influenced by changing the outflow. A second simulation of lake levels was therefore developed. This sequence of lake levels is shown in Plate 2.

Pigeon Lake regulation objectives of reducing peak levels, by 0.3 m

to reduce lakeshore flooding and erosion were selected following the July 4, 1980 information meeting held at Ma-Me-O Beach.

Alternative One for lake level control would involve replacement of the present lake outlet structure with a weir 5.0 m wide and a sill elevation of 849.8 m. Plate 1 illustrates the regulation effect of this alternative, with lake levels lowered by about 0.3 m over the simulation period.

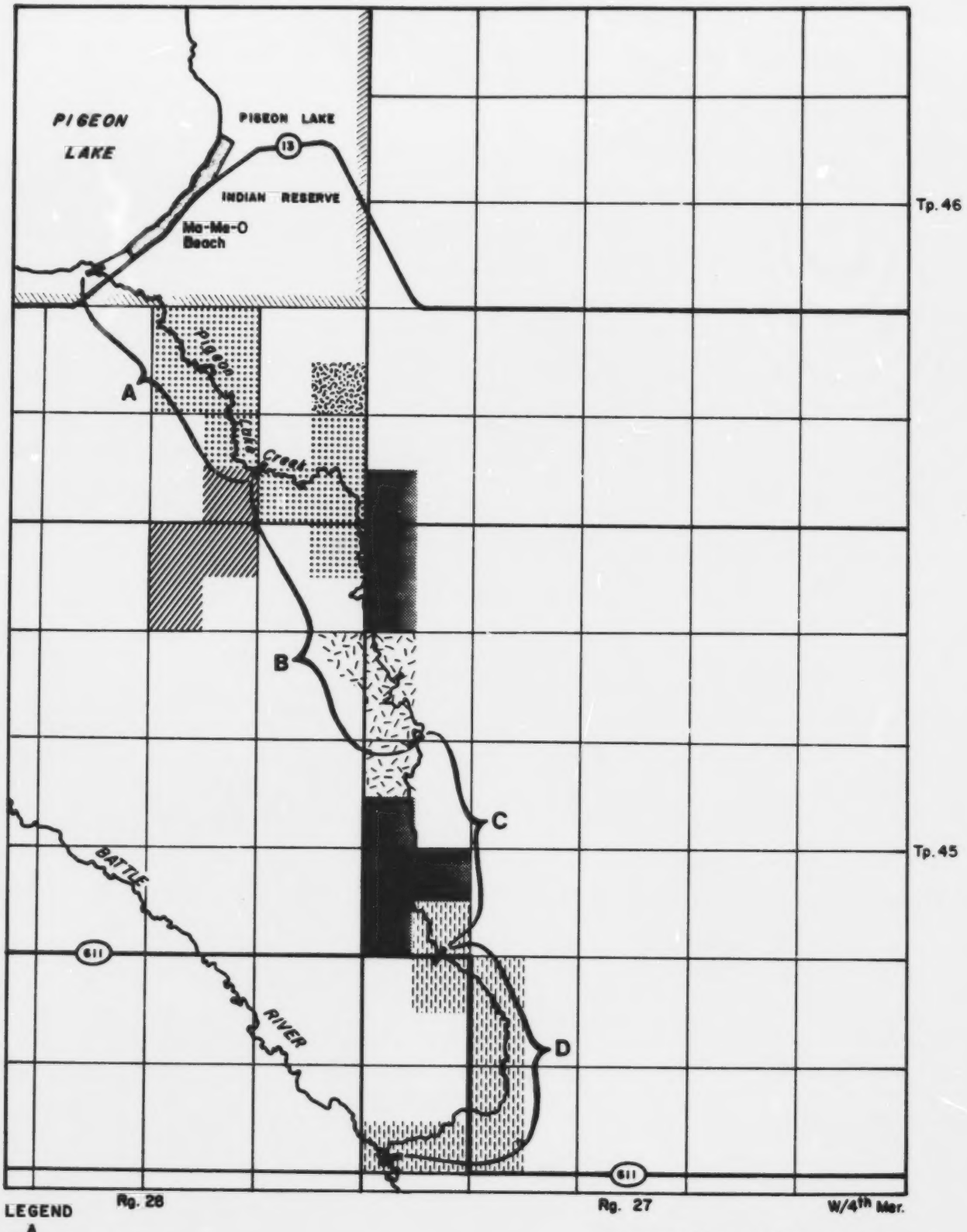
Alternativer Two, using a 6.0 m wide wier with sill elevation of 849.5 m, is shown on Plate 2 to reduce experienced lake levels by 0.6 m.

It is important to note that the lake level reductions accomplished by both alternatives extend over the complete sixteen year time-frame of the lake level model. The pattern of fluctuation does not change, and the maximum fluctuation range of 1.22 m is not reduced. Consequently, regulation of Pigeon Lake to reduce peak levels would force natural low lake levels in dry periods to drop even lower.

PIGEON LAKE CREEK

The data on Pigeon Lake Creek which predated the 1981 maintenance work is inadequate. Therefore, no quantitative comparisons can be made between existing and former channel capacities. The channel maintenance program of 1981 included cutoffs and widening which definitely increased channel capacity.

A survey of the creek was carried out following the maintenance program. The survey showed that the capacity of the creek did not increase progressively downstream and that reaches B and C (Figure 2) had a smaller capacity than reaches A and D. The capacities of the reaches have been estimated as follows:



GENERALIZED FLOODING ON PIGEON LAKE CREEK BASED ON QUESTIONNAIRE RESPONSES

FIGURE 2

Reach	Capacity m^3/s	Flood Event
A	2	1:3
B	2	< 1:2
C	2.8	< 1:2
D	5	< 1:3

The creek does not have a consistent overall capacity. Reach A, which is immediately downstream of the lake, can pass the 1.3 year flood provided there is no lake outflow. Reachs B and C, which are downstream of reach A, both have capacities less than the 1:2 year flood. Reach D, which is the farthest downstream, has greater capacity than reaches B and C but less than the 1:3 year flood.

To provide consistency in the channel and to allow for lake outflow as well as flow from the creek watershed a base lake outflow was selected. The average mean monthly lake outflow over the study period, taking into account only those months in which there was actual outflow, was chosen. With the different outflow capacities, the base flow for Alternative One will be 0.7 m^3/s and for Alternative Two, 0.8 m^3/s capacities along the length of the creek can then be developed consistent with reach A or reach D.

It was decided to use a lake outflow of 0.7 m^3/s and make the capacity of the entire creek consistent with reach D. This achieves flood protection to the level of the 1:2.5 year event all along the creek. The capacities required to do this are as follows:

Reach	Present Capacity (m^3/s)	Capacity Required Base D m^3/s
A	2	2.2
B	2	3.3
C	2.8	4.5
D	5	5.0

A set of culverts located between reaches C and D will have to be replaced.

OPERATIONS

Any replacement structure will have to be operated as originally proposed i.e stoplogs inserted as necessary to prevent summer flooding of downstream hay land. If the lake is completely shut off for one month lake levels will rise only about 0.06 m higher than they would be if outflow had occured.

COSTS

The present structure is in poor condition and the cost of replacing it, including a walkway, will be in the order of $70,000. The cost of these channelization works including culverts will be approximately $250,000.

ENVIRONMENTAL ASSESSMENT

PURPOSE

The purpose of this component was to identify the changes in aquatic plant growth and fishery that might occur as a result of regulating the lake levels. This could only be done for the lake, as major changes had been made to the creek in a maintenance program. Water quality concerns were raised after the study was under way and could therefore only be dealt with in a cursory manner.

METHODOLOGY

A survey of lake depth, sediment and plant growth was carried out in the littoral zone (the area where enough light for plant growth penetrates to the lake bottom). This information was mapped relative to the August, 1981 water level. The 1981 level was used to ensure comparability with cottagers' perceptions as reported in the questionnaire interviews.

Though the questionnaires were developed primarily for the socio-economic component of the study, they provided an excellent opportunity to obtain qualitative information on historical conditions relating to fish, water quality and vegetation. A few lake water quality samples were taken in the summer of 1981 for coliform and faecal coliform analysis.

AQUATIC PLANT GROWTH

Mr. Rick Haag of the University of Alberta and Mr. Leigh Noton of Chemical and Geological Laboratories Ltd. were hired to survey and map plant growth and sediment, and to predict the effect on aquatic

plant growth if lake levels were 2 m lower than at the time of the survey. This could be the low lake level achieved if present levels were dropped by 0.6 m.

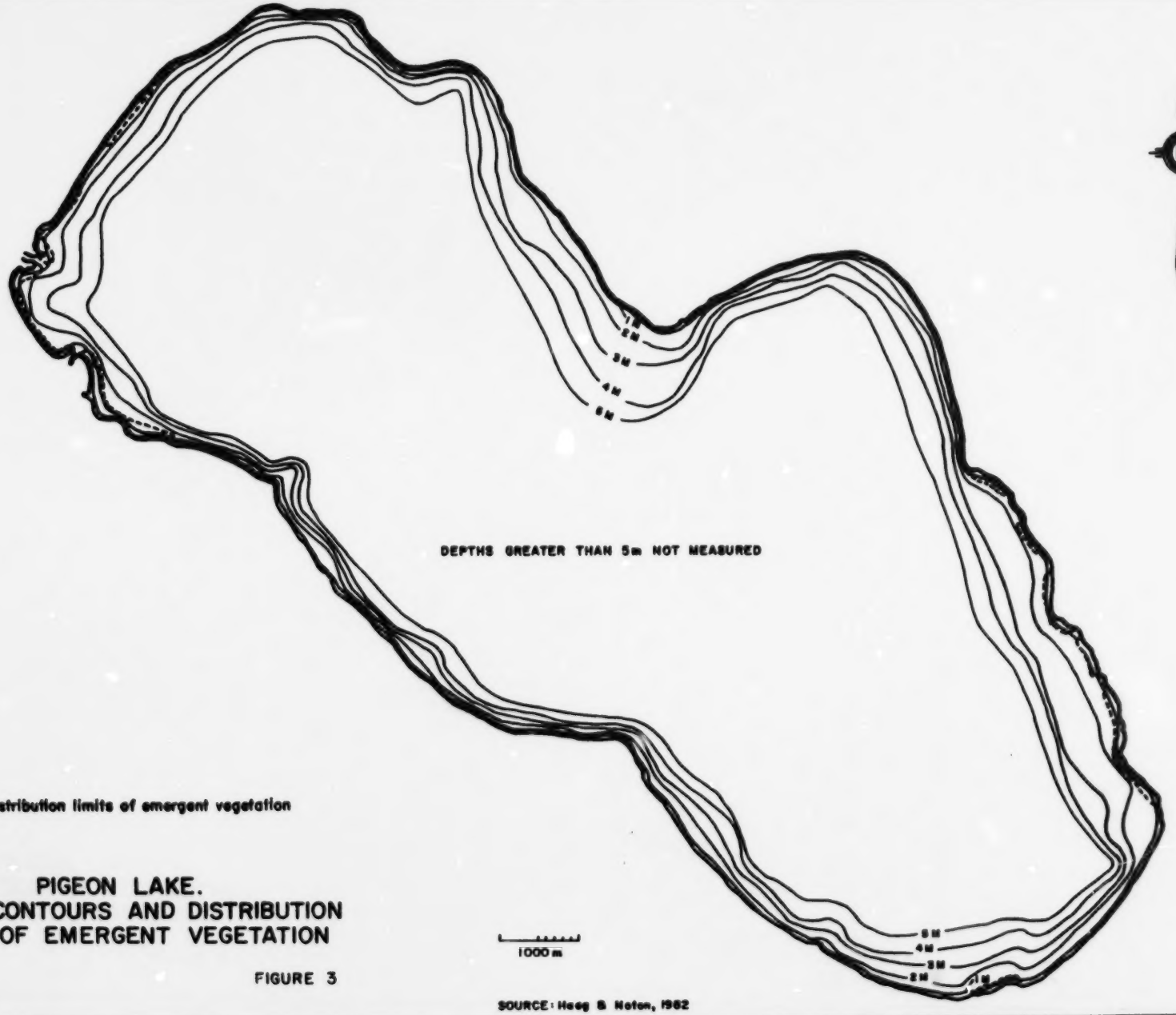
Figure 3 shows lake depths down to 5 m (the areas of lake deeper than this were not mapped). Figure 4 shows the distribution of different sediments in the lake. Fine textured sediments usually support more varied and more dense plant growth than coarse textured sediments.

Twenty-four species of submergent aquatic plants were found in Pigeon Lake. Milfoil (Myriophyllum exalbescens), muskgrass (Chara) and pondweeds (Potamogeton) were most common. These plants are typical of lakes like Pigeon Lake in depths up to 4.5 m. A surface cover of 30 - 50% will interfere marginally with diving and boat passage, 50 - 75% cover interferes noticeably and greater than 75% cover is almost unnavigable. Growth densities as low as 10% may interfere with swimming.

Thirty percent of respondents to the questionnaire survey had problems with weed growth. Milfoil and pondweed are probably the source of these problems. Lower lake levels will cause nuisance growths to become more obvious in some parts of the lake.

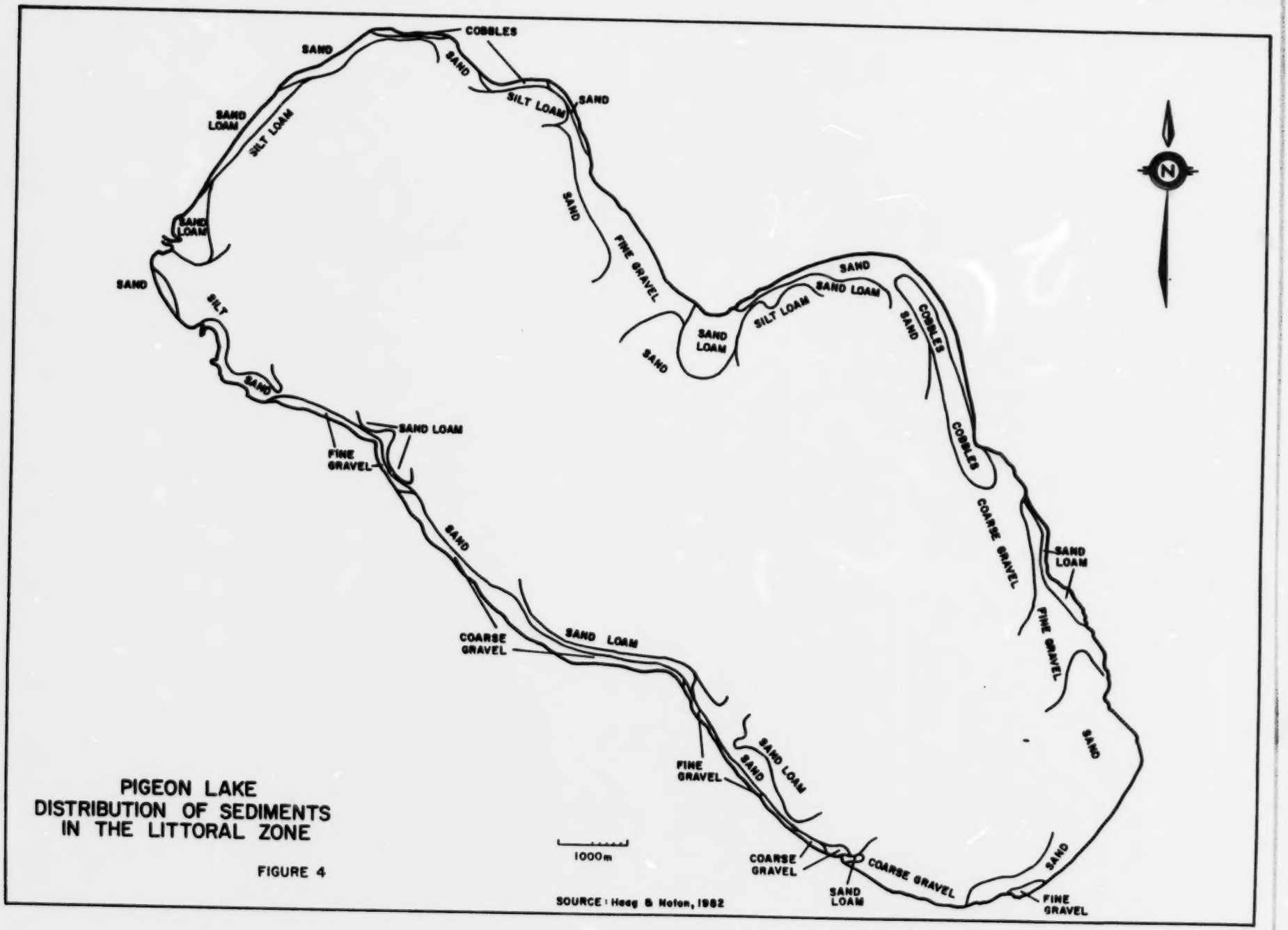
WATER QUALITY

Reducing lake levels by 0.3 m will have little effect on water quality. Seventy-four percent of the respondents to the questionnaire survey were concerned about water quality and the possibility of sewage contamination. Samples taken in the summer of 1981 were analysed for coliform and faecal coliform. The presence of large numbers of these



PIGEON LAKE.
DEPTH CONTOURS AND DISTRIBUTION
LIMITS OF EMERGENT VEGETATION

FIGURE 3



PIGEON LAKE
DISTRIBUTION OF SEDIMENTS
IN THE LITTORAL ZONE

FIGURE 4

organisms indicates sewage contamination. No serious problems were identified from these samples.

It seems inevitable that water quality problems will develop on a lake where such intensive cottage development has taken place. Pit toilets in sand and peat are not effective and though 20% of the cottages have pump-out tanks, many of these may not be properly managed. During low water years when the lake volume is reduced up to 20%, any sewage entering the lake will be more concentrated than it is now.

FISH

A lowering of lake level by 0.3 m below natural levels is unlikely to have a great effect on fish populations in the lake. Increased weed growth at low lake levels could lead to an increased pike population by providing weed beds for spawning and fry production.

A more significant change could result from the channelization of Pigeon Lake Creek from Pigeon Lake to the Battle River. Fish movement between these two water-bodies has likely been at least partially blocked in the past. If a fishway is incorporated into the weir, the species most likely to move into the lake are northern pike and white sucker, both of which are now in Pigeon Lake.

POTENTIAL EFFECTS OF REDUCED LAKE LEVELS

Plant growth is most luxuriant where sediment is fine textured and where light is optimal. In Pigeon Lake, optimal light conditions for aquatic plants occur at a depth of 1.5 - 3.5 m. By reducing lake levels, not only does the shoreline change but the littoral zone will increase, and the area where conditions encourage plant growth will increase also.

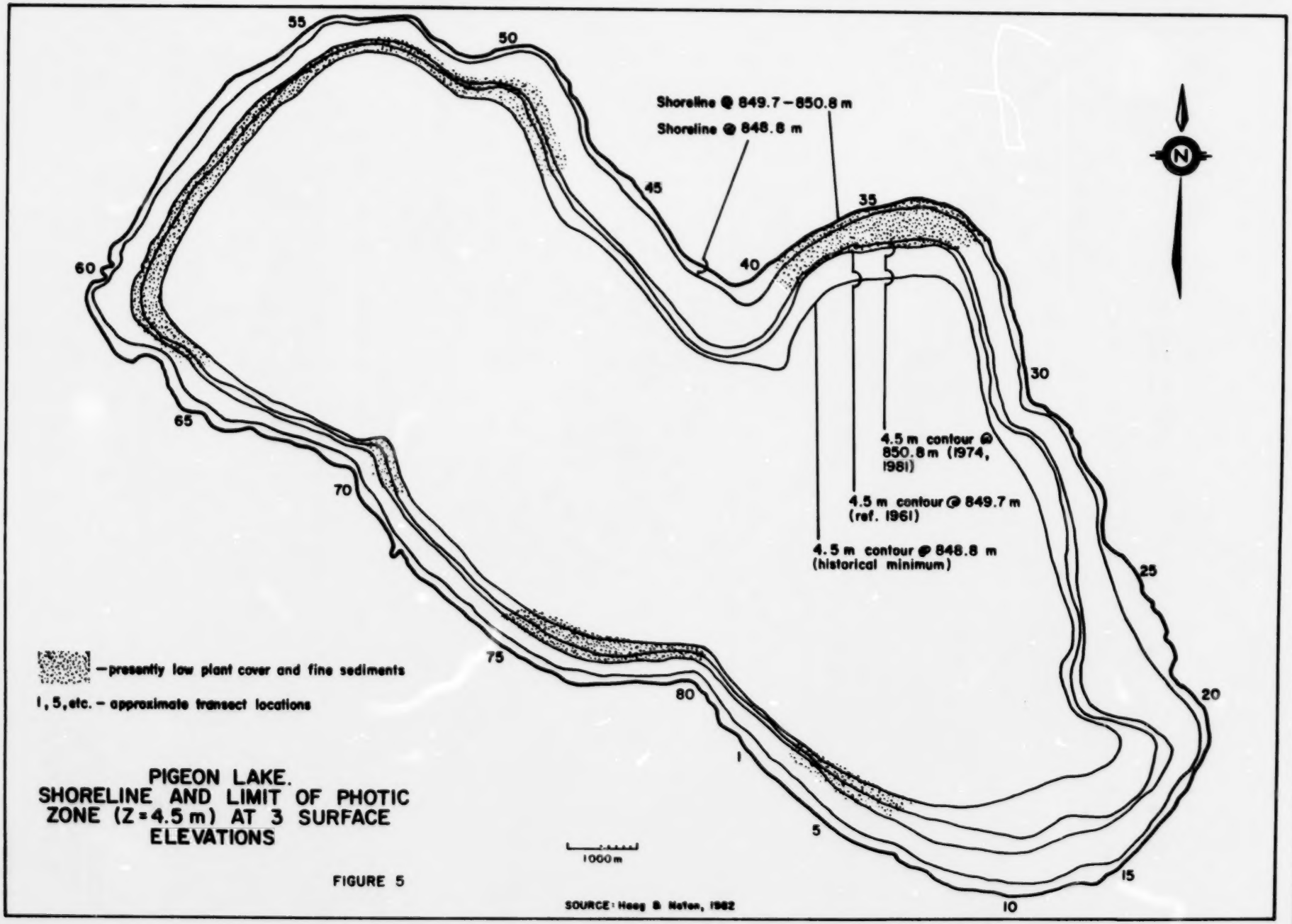
Figure 4 shows the areas of the lake where problems with nuisance growth could occur. Figure 5 shows the littoral zone and shoreline at difference lake levels. Areas such as Crystal Springs, Mulhurst and Argentia have little plant cover at present, but off-shore sediment is fine-textured. With lower water levels dense weed growth could develop. The transects shown in Figure 6 reflect the changes in plant growth that can be expected with changes in lake level.

During low water "muddy" wading areas may become more common. If levels stay low for an extended period (5 - 10 years), the natural action of the waves will wash the fine sediment back into deeper water.

The lower the final lake level, the more likely problems with vegetation are to occur. Also, as lake levels are reduced, the relative amount of time when conditions minimize growth is reduced also. This relationship is presented below.

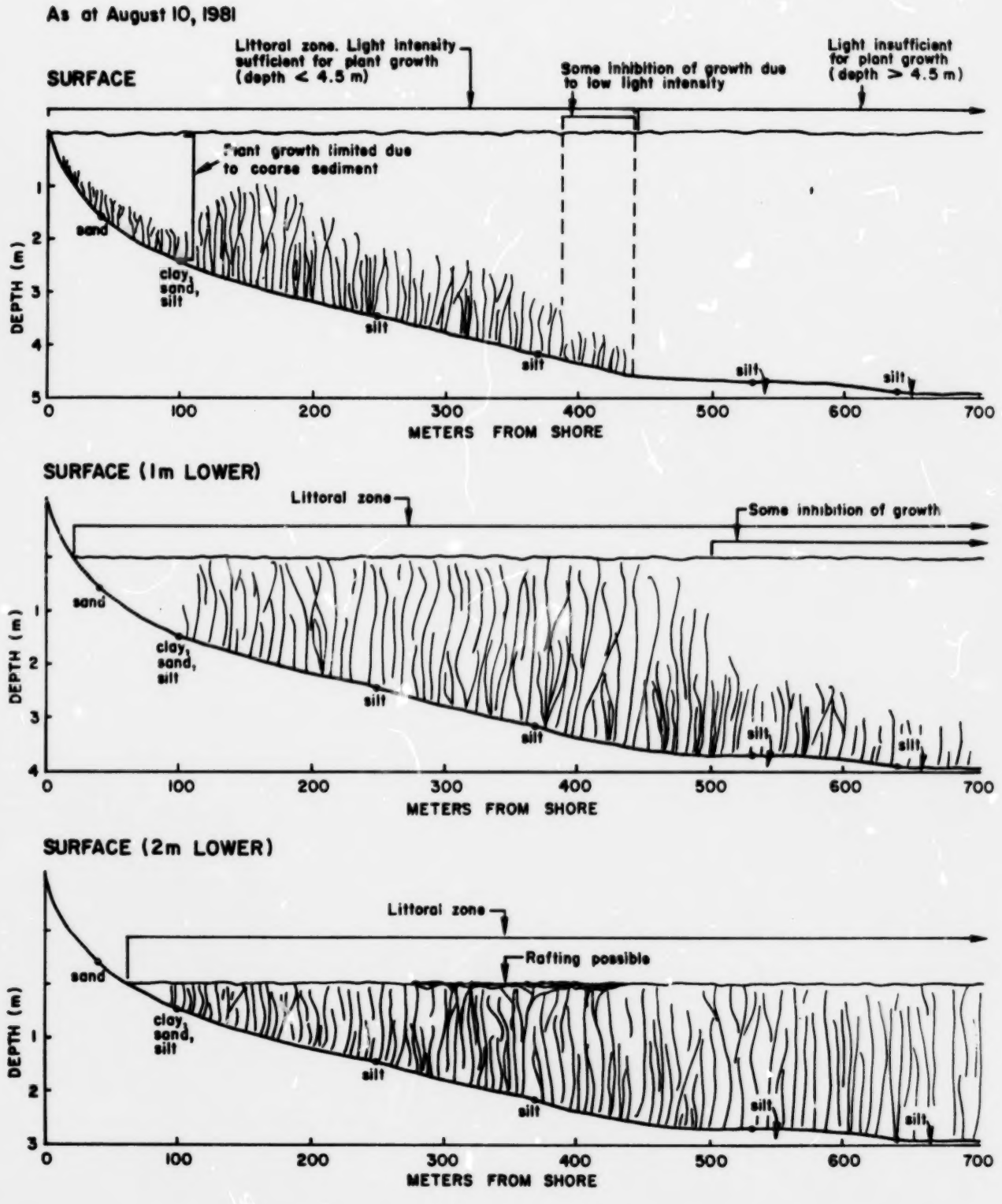
DURATION OF TIME WITH POTENTIAL AQUATIC WEED PROBLEMS IF HIGH LAKE LEVELS ARE REDUCED

LAKE LEVELS	HISTORIC		IF HIGH LEVELS REDUCED 0.3 m	
	# mo.	% of time	# mo.	% of time
1981 level to 1.0 m lower (849.8 - 850.8 m) little weed problem	227	66%	38	11%
1.0 m to 1.5 m lower than 1981 (849.3 - 849.8 m) some in weeds	118	34%	238	69%
1.5 m to 2.0 m lower than 1981 (848.8 - 849.3 m)	0	0	69	20%



PIGEON LAKE.
SHORELINE AND LIMIT OF PHOTIC ZONE (Z = 4.5 m) AT 3 SURFACE ELEVATIONS

FIGURE 5



TRANSECTS AT ARGENTIA BEACH AND PREDICTED VEGETATION AT THREE WATER LEVELS

FIGURE 6

Any reduction in lake levels will cause a reduction in lake volume. This will have the effect of concentrating nutrients and pollutants.

SOCIO-ECONOMIC STUDY AND PUBLIC PARTICIPATION

BACKGROUND

Department action on Pigeon Lake was instigated by public concern and contact was maintained with representatives of the area residents throughout the study. Two public meetings were held at Falun, in February and June of 1981, and an information session was held in July at Ma-Me-O Beach.

At the February meeting cottagers were concerned about the potential damage from flooding and erosion that high lake levels could cause. Farmers from Pigeon Creek expressed concern that the solution to the cottagers' problems could worsen flooding problems on the creek. Both farmers and cottagers were informed at this meeting that a study would be undertaken to investigate long-term solutions to high levels on Pigeon Lake and flooding on Pigeon Lake Creek.

At the June meeting further concerns were brought out. These centred on the possible pollution of the lake as a result of malfunctioning or inadequate onsite waste disposal systems. Information on this matter was requested from several government sources. Thorough investigation of these perceived problems was beyond the scope of the study (which was already underway), but a brief review was undertaken.

PUBLIC MEETINGS

Study personnel attended two public meetings coordinated by a committee of residents but neither meeting produced information concerning lake level preference.

An information session was subsequently held at Ma-Me-O Beach in July, 1981 to show residents the effects of altering the lake levels,

particularly the effects during periods of low water. To do this, the high and low lake levels that would have been experienced over the past 15 years if the lake had been lowered by 0.3 m, 0.4 m and 0.6 m were marked parallel to Ma-Me-O pier. (A similar exercise was conducted with staff of Recreation and Parks at the Provincial Park).

Information sheets about the lake levels, including a response sheet, were circulated before and during the information session. Responses were collected after the meeting and the information on preferred lake levels was tabulated.

As a result of this information session, Alberta Environment staff were invited to attend the annual general meetings of the summer villages of Ma-Me-O and Sundance. The objective in both cases was to respond to questions and concerns raised at the meeting. Neither meeting brought to light any problems other than those already identified at public meetings.

The lake level preferences expressed at the Ma-Me-O information meeting (Appendix B) were very evenly distributed among the possible alternatives and residents around the lake. No clear trend was apparent. Every effort was made prior to and at this information session to ensure that those responding were aware of the implications of their choice, and that it was impossible to maintain the lake at one static level. Still, comments appended to the responses indicate that the information was either misunderstood or ignored.

PURPOSE

One purpose of the socio-economic study was to determine the

nature, distribution and relative importance of the problems experienced by cottagers on the lake as a result of high lake levels. Secondly, it was necessary to evaluate the problems experienced by farmers as a result of cleaning the outlet structure.

METHODOLOGY

During July and August two questionnaire surveys were undertaken to provide a more accurate measure of public opinion and necessary socio-economic data. Farmers with operations along Pigeon Lake Creek were asked questions concerning farm size, land use, water supply, water shortage and flooding. The cottage owners of Pigeon Lake were asked about problems with low and high lake levels, environmental concerns and their preferred lake levels.

Summary tables of the results of the questionnaire survey are included in Appendix B.

SURVEY RESULTS

General

It is possible to make a few important generalizations about the results of the survey interviews. One is that lakeshore residents are more concerned about high levels than are backshore residents, because most lakeshore residents have experienced some problems with erosion. This difference in concerns is also apparent in preferences regarding regulation. Only 48% of the backshore residents interviewed want levels regulated compared with 76% of lakeshore residents.

There appears to be a concensus that low levels have not been a serious problem. This opinion does not differ significantly among the

various summer villages or between lakeshore and backshore residents.

Farmers

Any solutions other than "do nothing" would require the release of water through an outlet into Pigeon Lake Creek. Fourteen farmers were interviewed in summer 1981 to determine the possible effects on their operation if flows down Pigeon Lake Creek were increased.

Parts or all of 33 quarter-sections could be affected if the flows down Pigeon Lake Creek are altered. Because there are limited data concerning frequency-discharge relationships, it is not possible to estimate with any accuracy the actual impacts on these farming operations.

The 1980 flood, which resulted in substantial crop loss, must be regarded as a unique event. Generally, flooding has not been a serious problem along Pigeon Lake Creek, although there is one reach where approximately 300 acres are damaged almost every year. When flooding does occur, beaver dams are the usual cause. In most cases the land dries quickly.

Some operations use the creek as a source of water for cattle. In dry years shortages have been experienced. Farmers do not regard this as a serious problem because alternative sources, such as wells, are available.

It is reasonable to suggest that, under natural conditions, flows through Pigeon Lake Creek do not cause serious problems to farm operations along the creek.

Cottagers

One hundred and eighty-eight cottagers around the lake were interviewed in the summer of 1981. This sample is representative of the proportion of total residents in each summer village and of the proportions of lakeshore and backshore residents within each summer village.

Low Lake Levels

In general, low lake levels were not considered to be a serious problem. Only 31 (16%) of the 188 people interviewed expressed concern. Of the 90 who have resided at the lake longer than 15 years (long enough to have experienced previously low levels), only 20 (22%) say that low levels have ever been a problem. The problems described are generally related to sandbars and other boating inconveniences. Only at Golden Days and Ma-Me-O Beach, where one half and two thirds of the lakeshore residents respectively state that there were problems, do a significant proportion of respondents complain. In general, backshore residents do not feel that low levels create problems.

Some people expressed concern about regulating high levels if regulation would cause dry year levels to be lower than would occur under "natural" conditions.

High Lake Levels

Most lakeshore residents feel that high levels are a problem. Only 17 of the 123 lakeshore owners questioned (14%) say that there is no serious problem. By contrast, 38 of the 65 backshore residents (59%) feel that there is no problem.

Erosion is by far the most frequently mentioned concern. Of 133 people concerned about high levels, 106 (86%) cite erosion as a problem. In most cases erosion began or has intensified within the past five years. Approximately half of the cottagers facing erosion problems have installed some apparatus (e.g. retaining wall) to alleviate the problem. Length of residence does not seem to affect response; if anything, a slightly higher proportion of long-term residents (16 years or more) feel that there are problems. Concern about high levels by lakeshore residents is not confined to any specific part of the lake. Only at Ma-Me-O Beach do a significant proportion of respondents state that high levels are not a serious problem.

A significant number of lakeshore residents state that they have experienced other problems in addition to erosion. Twenty-eight of the 123 respondents (23%) mention damage or inconvenience regarding piers or boathouses. The highest number of complaints (7) is at Sundance Beach.

At Golden Days 12 of the 14 (86%) people interviewed complain of problems with high levels. Each claims that erosion is a problem. In addition there are seven complaints about flooding and four about problems with sewage disposal. Argentia Beach is another summer village where problems with sewage systems are a concern. It should be noted that flooding generally refers to water on the cottage lot that did not recede quickly. There are no instances of flood damage to cottages.

Backshore residents are less concerned with high lake levels. Sixty-three percent of those interviewed feel that there are no problems. Only at Mulhurst do a majority of those interviewed state that high levels were a problem.

PREFERENCES FOR REGULATED LEVELS

It was explained that it would be technically possible to regulate lake levels so that high levels would not be as high as they were in 1980 and 1981. It was also explained that an effect of regulation would be to lower "natural" levels during a dry period. Respondents were asked if they wanted levels to be regulated and, if so, how far below July, 1981 levels.

Five of the 188 respondents (3%) had no opinion. There were 63 (34%) who did not want the lake to be regulated and 81 (43%) who wanted the levels reduced by 12 inches or less. Another 22 (12%) said that they would have liked high levels reduced by 13 to 18 inches and 17 people (9%) wanted high levels reduced by 19 inches or more.

In only three summer villages (Ma-Me-O Beach, Mission Beach and Fisher Home) did a majority of the respondents not want the lake levels to be regulated. In the other summer villages, a reduction of high levels by 12 inches or less was preferred.

It is worth noting that 110 of the 130 (85%) respondents who said that high levels were a problem, did not want to live with the problems. They wanted action. Ninety-one of the 105 (87%) shorefront residents who had problems wanted action.

CONCLUSIONS

1. The existing outlet structure at Pigeon Lake is in disrepair and needs to be replaced.
2. Lake outlet analysis using a monthly lake water balance model (1965-1980) indicates that it is technically possible to reduce peak lake levels, but it is essentially impossible to reduce the net lake level fluctuation range. That is, a one foot reduction of high levels will result in an equivalent reduction in low levels.
3. For the purposes of the study, the base case of conditions has, the outlet structure silted in and a restricted creek capacity. The 1981 clearing of the structure and channelization of the creek will effectively maintain lake levels about 0.3 m lower than before.

Pigeon Lake Levels

4. The August 1981 lake levels were used as a benchmark for the questionnaire, and were the second highest on record. These levels were perceived to be too high by a majority of respondents.
5. With respondents aware of the implications of lowering high levels;

   of 123 foreshore respondents 24% want no change in lake level,
   50% want a reduction of 0.3 m
   25% want a reduction of 0.3 m - 0.6 m
   1% have no opinion.

   Of 65 backshore respondents 52% want no change in lake level,
   31% want a reduction of 0.3 m
   13% want a reduction of 0.3 m - 0.6 m
   1% want a reduction of more than 0.6 m
   3% have no opinion.

The differences between the fore and backshore respondents can probably be attributed to their experiences with erosion or property damage.

6. No change in base case conditions
   a) is supported by 50% of lakeshore respondents.
   b) is supported by 31% of backshore respondents.
   c) would require a smaller outlet structure with a higher sill elevation than the one presently in place.
   d) would result in relatively weed free high water levels for 66% of the time and moderate increases in weeds for 34% of the time. For only 10% of the time should severe weed and possible mud problems occur.
   e) would not change concentrations of either nutrients or pollutants in the lake.
7. A reduction in lake levels of about 0.3 m
   a) is supported by 25% of lakeshore respondents.
   b) is supported by 31% of backshore respondents.
   c) would require an outlet structure 5 m wide with a sill elevation of 849.8 m.
   d) would reduce the high water weed free periods from 66% to 11% of the time, and introduce a more severe weed problem and possibly muddy beaches for 20% of the time.
   e) will reduce lake volume and result in greater concentrations of nutrients and pollutants.
8. A reduction in lake levels of between 0.3 m and 0.6 m
   a) is supported by 25% of lakeshore respondents.
   b) is supported by 13% of backshore respondents.

c) an outlet structure 6 m wide with a sill elevation of 849.5 m would lower levels by about 2 ft.

d) would reduce the high water weed free periods from 66% to 7% of the time, and introduce a more severe weed problem, possibly muddy beaches for 45% of the time.

e) will further reduce lake volume and result in greater concentrations of nutrients and pollutants.

9. A walkway will be required on any structure for operational reasons and in response to Indian requests.

10. Any structure must permit fish passage.

11. An outlet structure would cost about $70,000.

12. The original intent of the structure is unchanged, outlflow from the lake should not aggravate downstream flood conditions on Pigeon Lake Creek during haying.

Pigeon Lake Creek

13. Flooding along Pigeon Lake Creek should not be made worse by the implementation of a scheme to lower the lake. The pre-1981 data needed as a base to determine the creek capacity requirements does not exist.

14. Work done along the creek by Alberta Environment in 1981 appears to have substantially increase creek capacity.

15. The present channel does not have a consistent capacity along its length.

16. To achieve consistent capacity, the capacity of reach B should be upgraded from 2 m^3/s to 3.3 m^3/s and for reach C from 2 m^3/s

to 4.5 m^3/s. This will provide for a base flow of 0.7 m^3/s -- average mean monthly lake outflow between 1965-1980 -- and will make the rest of the creek consistent with reach D which floods infrequently.

17. Before the capacity of reach C can be upgraded to 4.5 m^3/s the culverts at the end of the reach (at present about 1 m above the bed) will have to be lowered. It may also be necessary to lower the pipelines crossing the creek in reaches B and C and provide more set-back.

18. Some pipelines crossing the creek may have been affected by the 1981 program and may have to be lowered to achieve prescribed minimum cover and set-back.

19. Periodic maintenance to ensure reasonable capacity in the creek will be required.

Water Quality

20. 74% of the respondents are concerned about lake water quality, particularly possible sewage contamination.

RECOMMENDATIONS

1. Alberta Environment should immediately undertake to replace the deteriorated Pigeon Lake outlet structure. Design parameters should include a 5 m wide weir with a fixed sill elevation of 849.8 m, stoplogs for closure during downstream harvest, and provision for fish passage. Negotiations with the Four Band Council for survey and construction access plus long term access for operations and maintenance is a priority activity.
2. Annual operational guidelines for placing/removing stoplogs from the lake outlet structure, to facilitate downstream harvesting, are
   a) no stoplogs in place prior to July 1;
   b) no stoplogs in place after October 1;
   c) stoplogs placed when combined lake outflow and creek flow is approaching bankful capacity;
   d) stoplogs removed sequentially as creek flow subsides;
   e) maximum time of zero lake outflow with stoplogs in place is 30 days over the July to September period.
3. The 1981 Pigeon Creek channelization program should be upgraded to a flow capacity of 2.2 m m^3/s at the bottom of reach A, 3.3 m^3/s at the bottom of reach B and 4.5 m^3/s at the bottom of reach C, to allow for 0.7 m^3/s base outflow from Pigeon Lake, plus an approximate 1:2.5 year flood control for Pigeon Creek. Cost of excavation and pipeline lowering is in the order of $250,000.

REFERENCES

Alberta Environment, Planning Division, 1982, "Pigeon Lake Regulation Feasibility Study. Alberta Environment, Edmonton.

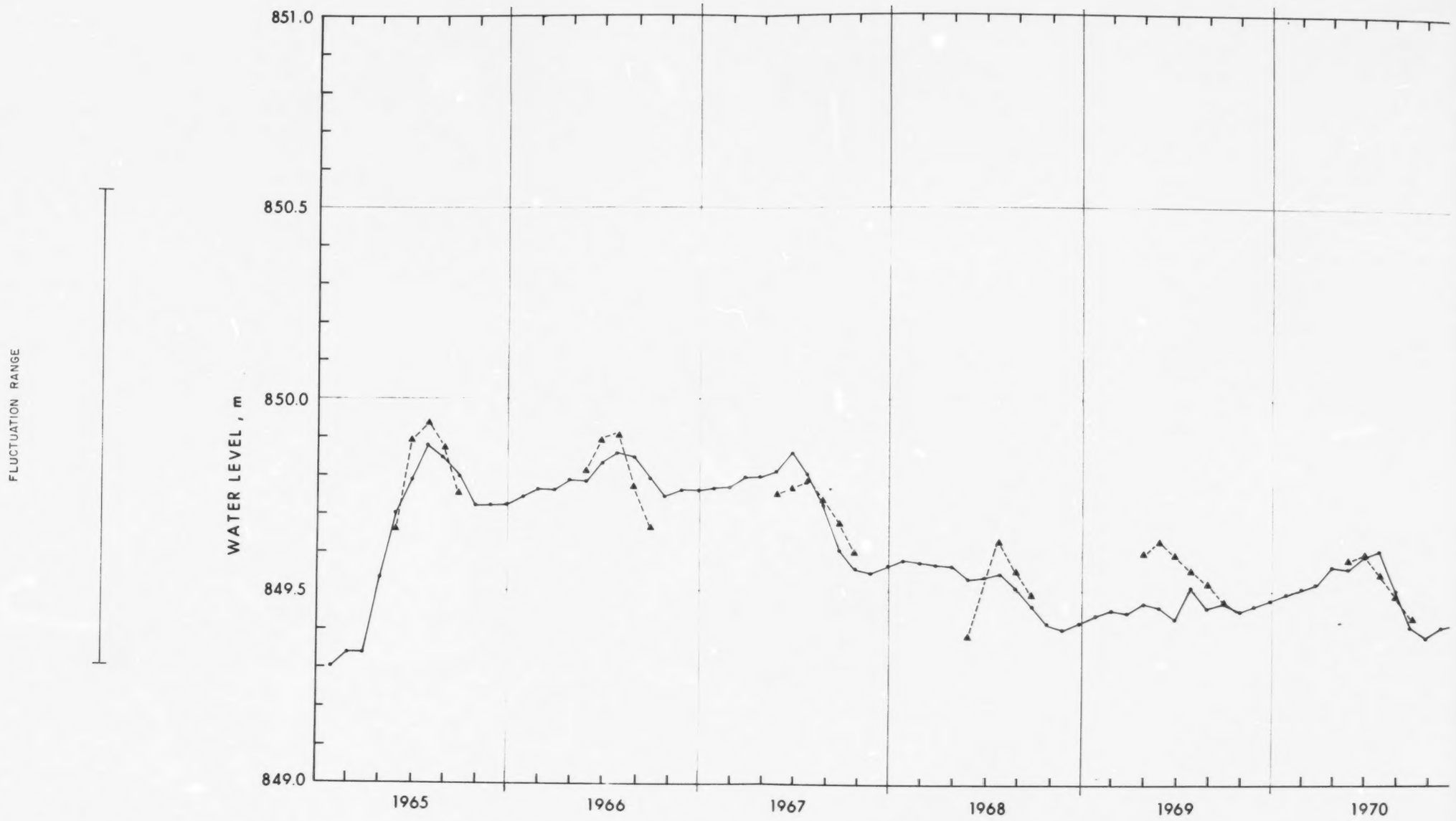
Battle River Regional Planning Commission and Edmonton Regional Planning Commission, 1974, "Pigeon Lake Study" E.R.P.C. B.R.R.P.C.

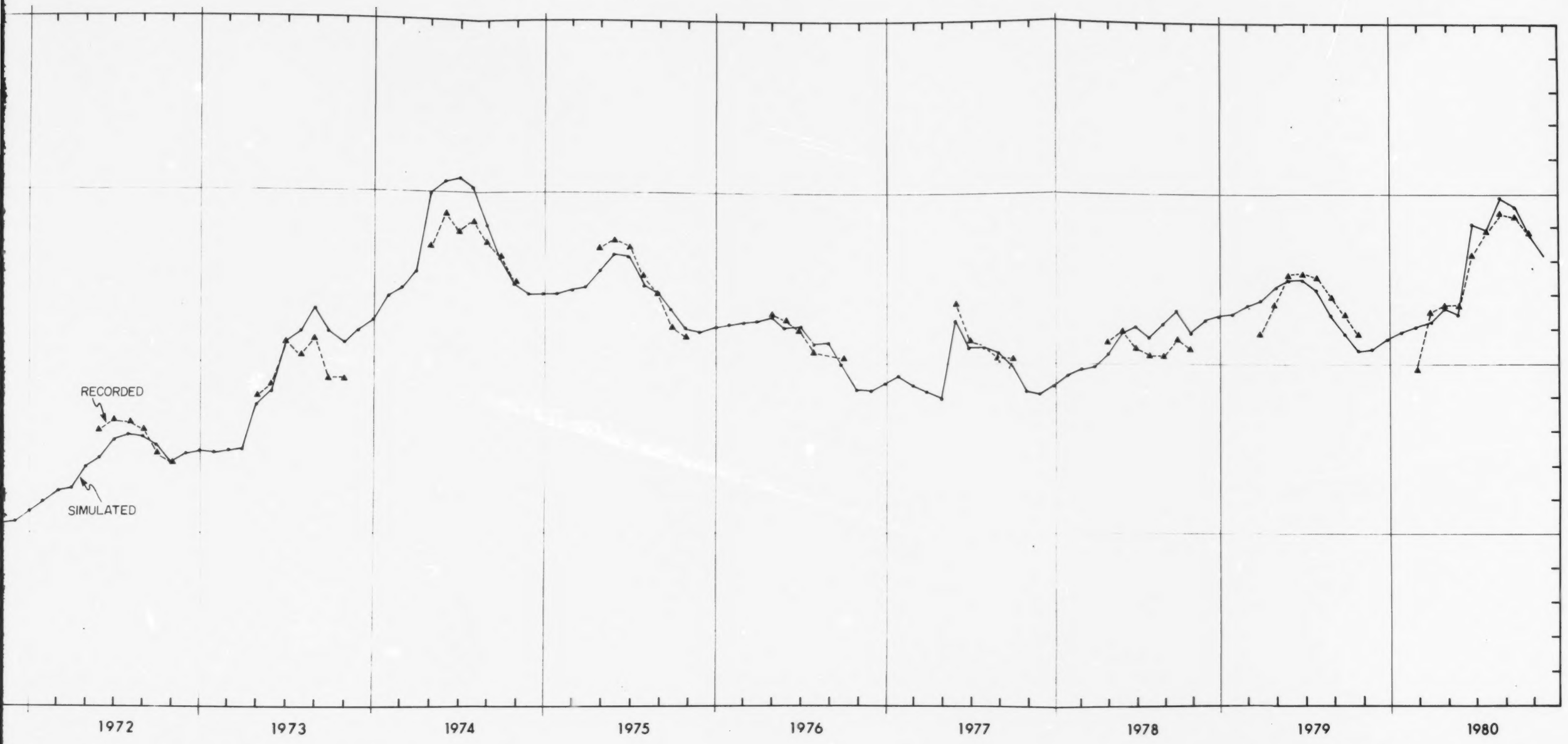
Haag R. &Noton L. 1981 "Pigeon Lake Macrophyte and Littoral Sediment Survey"
Alberta Environment, Edmonton.

Northwest Hydraulic Consultants Ltd, 1981 "Pigeon Lake Regulation Study"
Alberta Environment, Edmonton.

APPENDIX A

PLATES


FLUCTUATION RANGE
WATER LEVEL , m
851.0
850.5
850.0
849.5
849.0
1965
1966
1967
1968
1969
1970

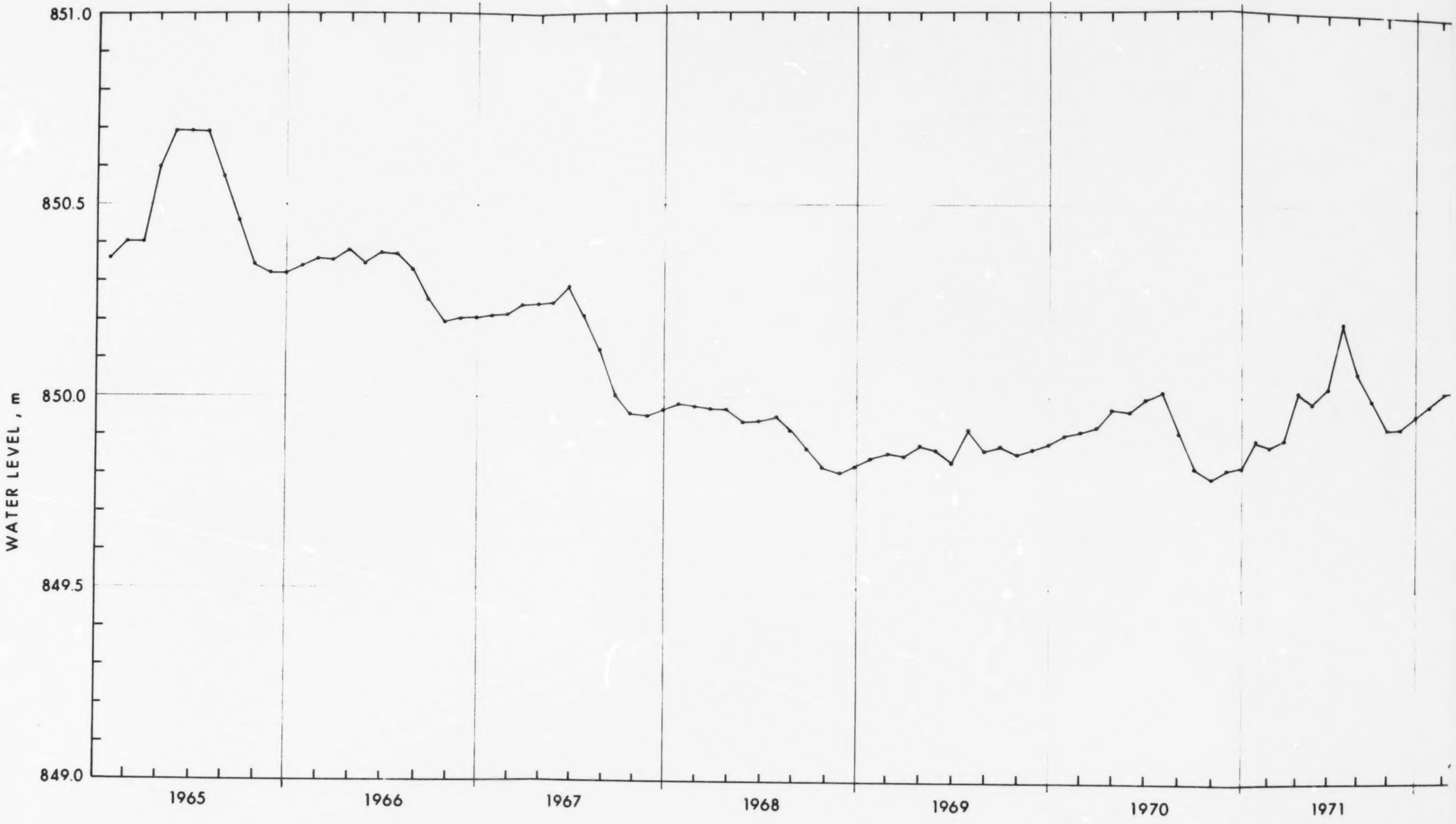


PIGEON LAKE / PIGEON LAKE CREEK REGULATION FEASIBILITY STUDY

MEASURED AND SIMULATED HISTORIC LEVELS , 1965-80

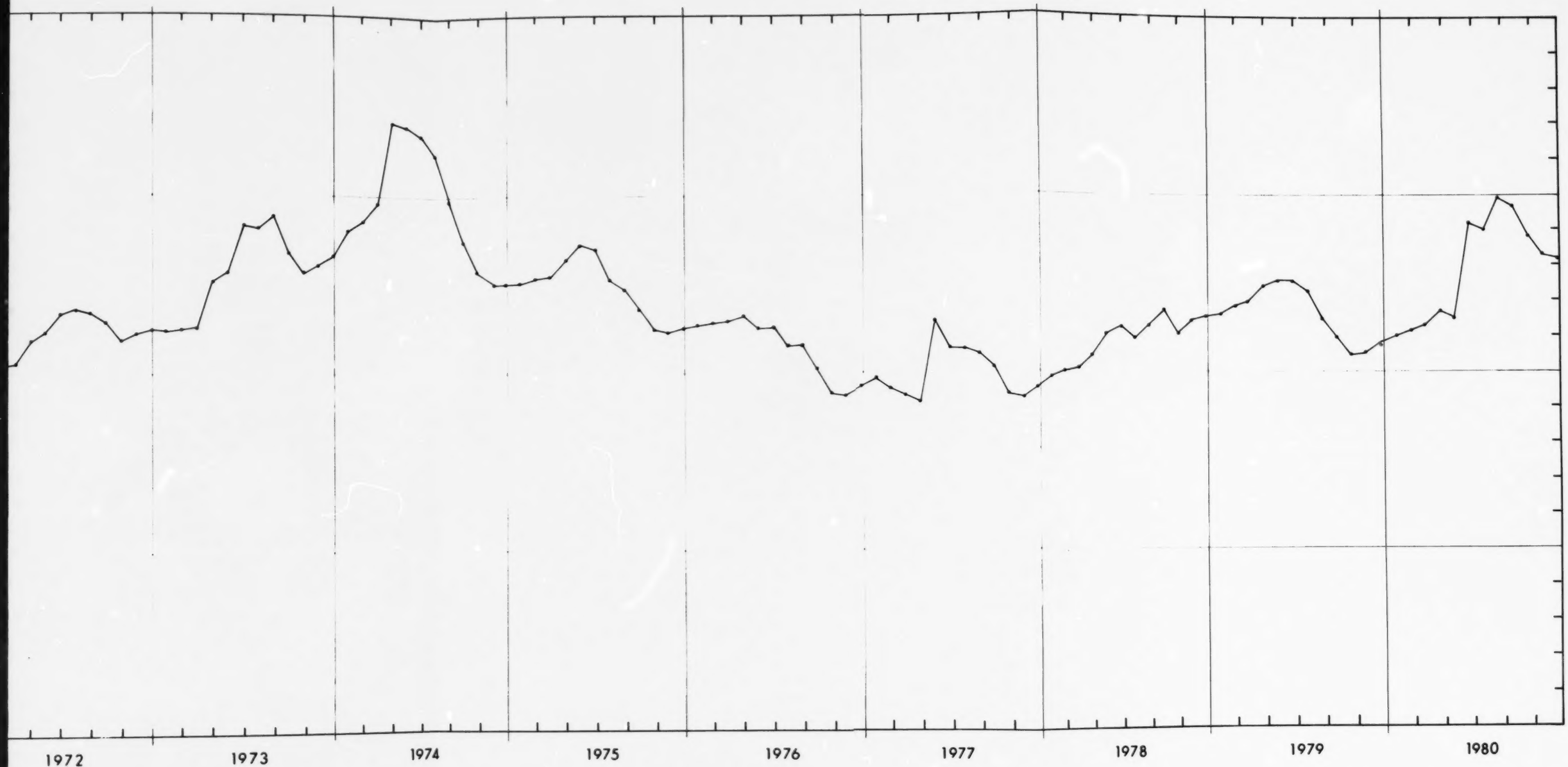
PLATE 1

FLUCTUATION RANGE



NOTES:

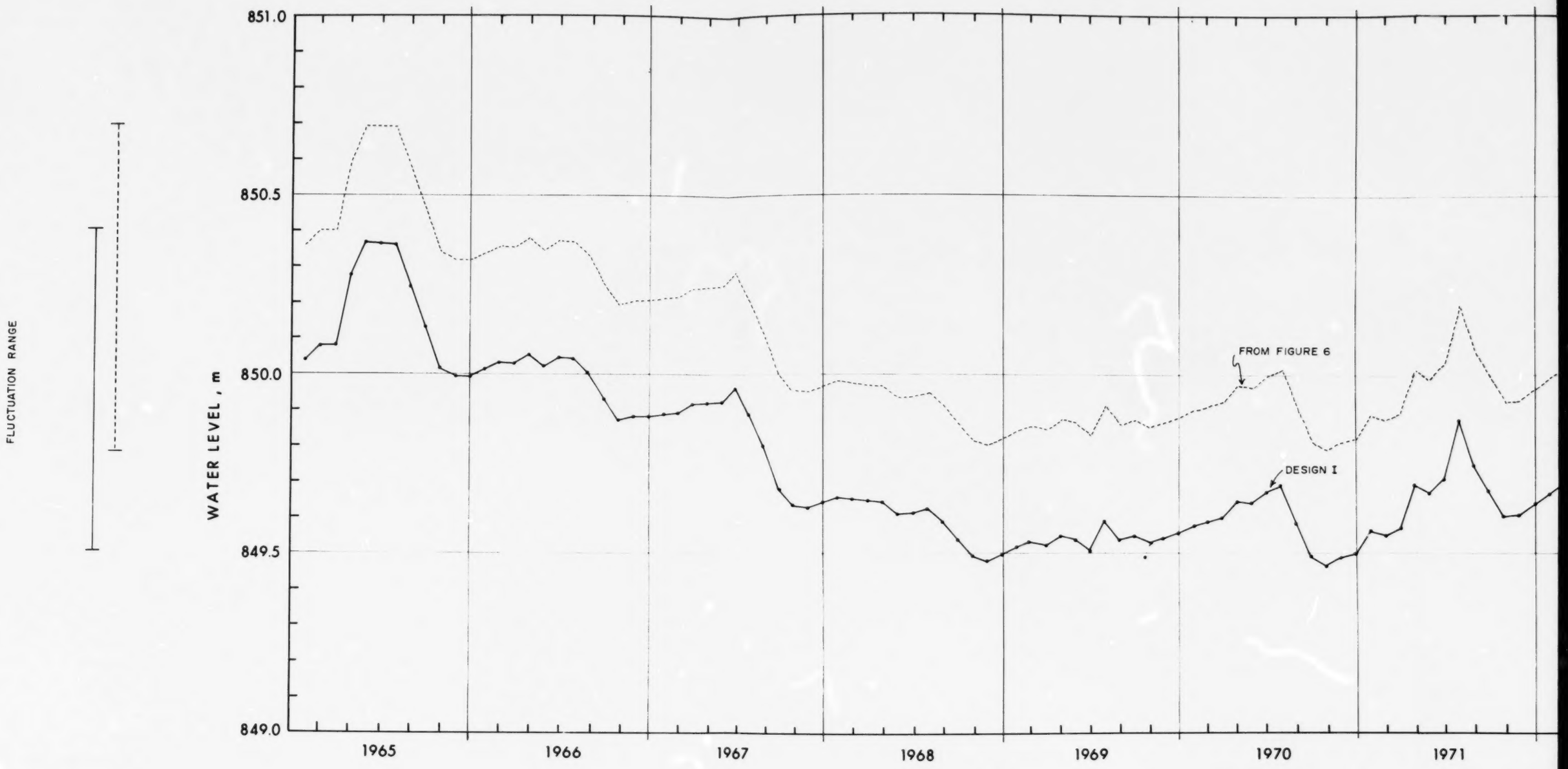
STARTING ELEVATION IS AS DECEMBER 1980 ELEVATION OF FIGURE 5. 1965-1980 HYDROLOGIC SEQUENCE ASSUMED REPEATED.



PIGEON LAKE / PIGEON LAKE CREEK REGULATION FEASIBILITY STUDY

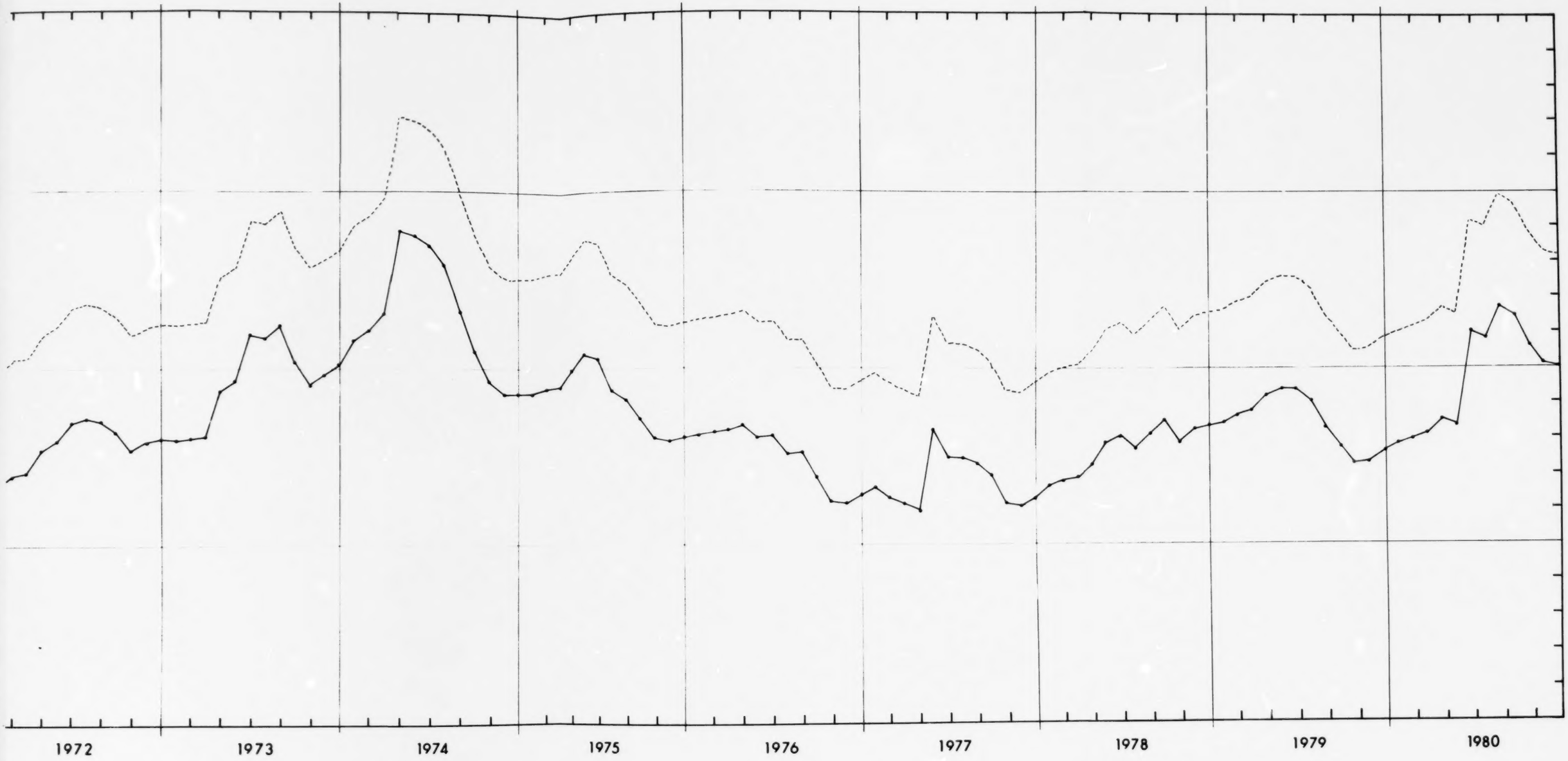
ARTIFICAL LAKE LEVEL SEQUENCE, 1965-80

PLATE 2



NOTE:

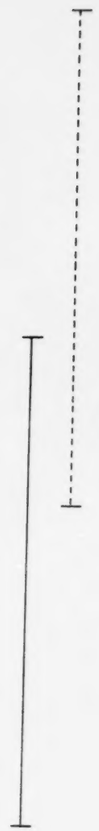
SECOND SIMULATION OF 1965-1980 HYDROLOGIC SEQUENCE

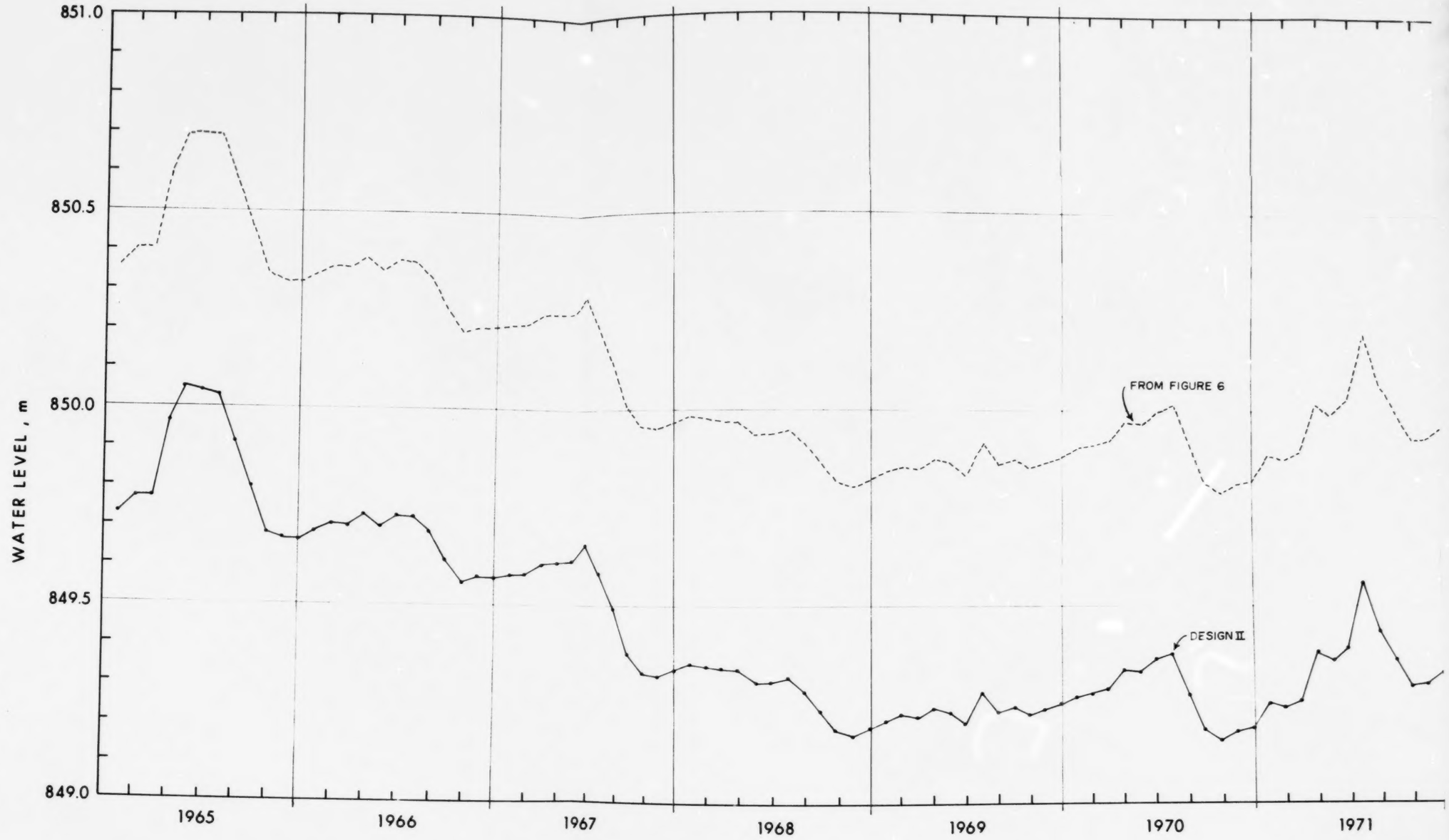


PIGEON LAKE / PIGEON LAKE CREEK REGULATION FEASIBILITY STUDY

EFFECT OF ALTERNATIVE I ON ARTIFICIAL SEQUENCE

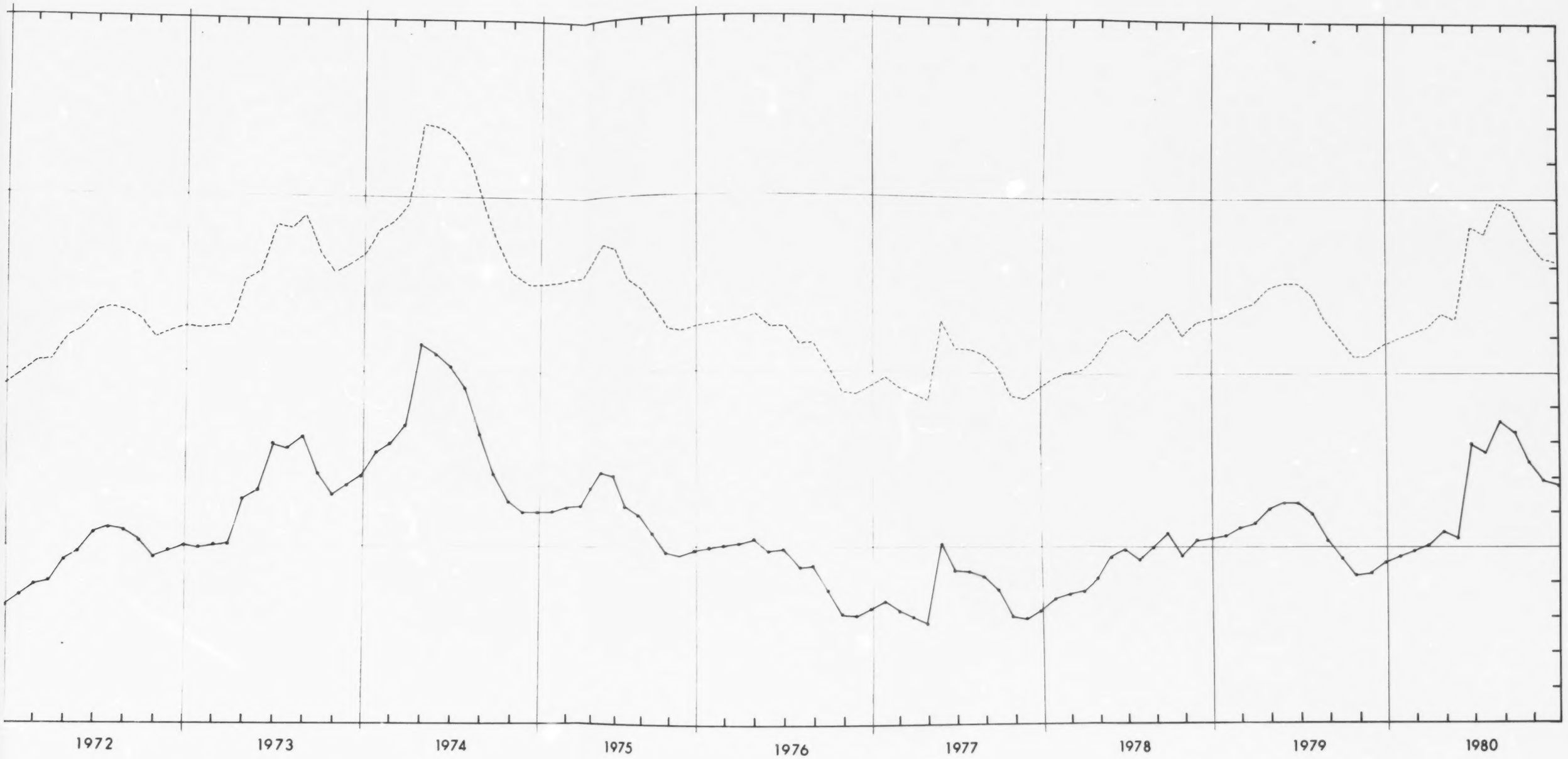
PLATE 3





NOTE:

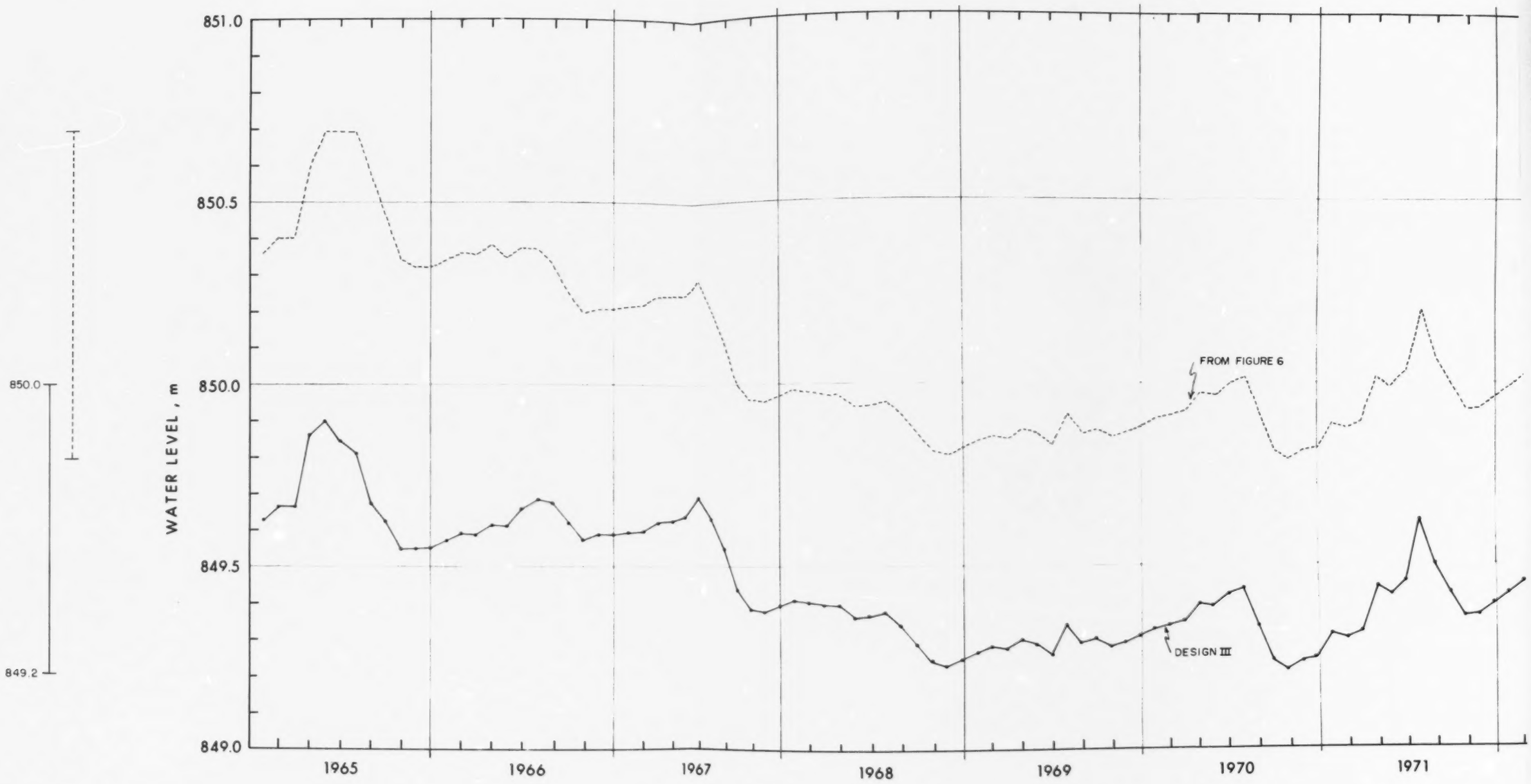
SECOND SIMULATION OF 1965-1980 HYDROLOGIC SEQUENCE



PIGEON LAKE / PIGEON LAKE CREEK REGULATION FEASIBILITY STUDY

EFFECT OF ALTERNATIVE 2 ON ARTIFICIAL SEQUENCE

PLATE 4



NOTE:

SECOND SIMULATION OF 1965-1980 HYDROLOGIC SEQUENCE

1972 1973 1974 1975 1976 1977 1978 1979 1980

PEGEON LAKE / PEGEON LAKE CREEK REGULATION FEASIBILITY STUDY

EFFECT OF DESIGN 3 ON ARTIFICAL SEQUENCE

PLATE 5

APPENDIX B

SURVEY RESPONSES

TABLE 1

MA-ME-O - JULY 4TH
INFORMATION MEETING
LAKE LEVEL PREFERENCES

PLACE OF RESIDENCE	0.3 m LOWER* ORANGE	0.4 m LOWER* YELLOW	0.6 m LOWER* GREEN	NO CHANGE	NO FLUCTUATION**	TOTAL
Non-resident		3	6	1	1	11
Mulhurst			2			2
Viola	15	3		2		20
Fisher Home	1	1				2
Poplar Bay	1	1	3		2	7
Crystal Spring	2	2	1	1		6
Ma-Me-O	7	14	7	17	5	50
Sundance		4			1	5
Golden Days	1	1			2	4
Morris	3	2	3		5	13
Itaska	1	1				2
Grandview	3	1	11			15
Silver Beach	1		1	1	4	7
Argentia	5	4	5		14	28
TOTAL	40	37	39	22	34	172

* Refers to 1974 high level. Colours relate to the different lake level markers used at the pier.

** This category was added after the meeting.

TABLE 2a

LAKEFRONT RESIDENTS - PROBLEMS WITH LOW LEVELS

Summer Village	Number Visited	No Problems	Sandbars	Weeds	Boating	Others
Silver Beach	8	7				1
Argentia Beach	11	8		1	1	2
Golden Days	14	7			5	3
Itaska Beach	8	8				
Mitchell Beach	2	1			1	1
Moonlight Bay	4	4				
Sundance Beach	13	13				
Fisher Home	5	4	1	1		1
Norris Beach	4	4				
Grandview	15	13		1	2	
Poplar Bay	12	8		2	1	2
Viola Beach	5	5				
Crystal Springs	13	9		4		
Ma-Me-O Beach	9	3	4	4	1	
TOTAL	123	94	5	13	11	10

TABLE 2b

BACKSHORE RESIDENTS - PROBLEMS WITH LOW LEVELS

Summer Village	Number Visited	No Problems	Weeds	Sandbars	Difficult Boating	Swimmer's Itch	Other
Mulhurst	5	4	1			1	
Silver Beach	4	4					
Golden Days	6	5				1	
Mitchell Beach	1	1					
Moonlight Bay	1	1					
Mission Beach	8	6			2		
Sundance Beach	1			1			
Norris Beach	4	4					
Grandview	10	8	1		1		
Poplar Bay	4	4					
Crystal Springs	5	5					
Ma-Me-O Beach	16	11	2	2	2		1
	65	53	4	3	5	2	1

TABLE 3a

LAKEFRONT RESIDENTS - LENGTH OF RESIDENCE VS. PERCEPTION OF LOW LEVELS

Summer Village		Years at Lake				Total
		0-5	6-10	11-15	16+	
Silver Beach	p			1		1
	t	1		3	4	8
Argentia Beach	p			1	2	3
	t			2	9	11
Golden Days	p		3	1	3	7
	t		7	4	3	14
Itaska Beach	p					0
	t			2	6	8
Mitchell Beach	p	0				0
	t	2				2
Moonlight Bay	p					0
	t	2			2	4
Sundance Beach	p					0
	t	2	2	2	7	13
Fisher Home	p			0	1	1
	t			1	4	5
Norris Beach	p					0
	t	1	2	1		4
Grandview	p				2	2
	t	1	2	1	11	15
Poplar Bay	p					0
	t		3	2	7	12
Viola Beach	p					0
	t		2		3	5

(continued)

		Years at Lake				Total
		0-5	6-10	11-15	16+	
Crystal Springs	p			2	2	4
	t		2	5	6	13
Ma-Me-O Beach	p		2		4	6
	t	2	2	1	4	9
	p	0	3	5	14	22
	t	11	22	24	66	123

p = number of respondents who said they had experienced problems

t = total who were interviewed

TABLE 3b

BACKSHORE RESIDENTS - LENGTH OF RESIDENCE VS.
PERCEPTION OF LOW LEVELS

Summer Village		Years at Lake 0-5	6-10	11-15	16+	Total
Mulhurst	p	0			1	1
	t	3			2	5
Silver Beach	p		0	0	0	0
	t		2	1	1	4
Golden Days	p	0	1			1
	t	2	4			6
Mitchell Beach	p		0			0
	t		1			1
Moonlight Bay	p			0		0
	t			1		1
Mission Beach	p	0		1	1	2
	t	1		3	4	8
Sundance Beach	p				1	1
	t				1	1
Morris Beach	p	0	0	0		0
	t	1	2	1		4
Grandview	p	0	1	0	1	2
	t	3	2	2	3	10
Poplar Bay	p	0	0			0
	t	2	2			4

(continued)

Summer Village		Years at Lake 0-5	6-10	11-15	16+	Total
Crystal Springs	p	0	0		0	0
	t	2	1		2	5
a-Me-O Beach	p	0	0	0	2	2
	t	1	1	3	11	16
totals	p	0	2	1	6	9
	t	15	15	11	24	65

p = number of respondents who said they had experienced problems.

t = total that were interviewed.

TABLE 4a

LAKEFRONT RESIDENTS - PROBLEMS WITH HIGH LEVELS

Summer Village	Number Visited	No Problems	Erosion	Flooding	Piers or Boathouses	Sewage	Less Beach	Drainage	Other
Silver Beach	8		8	1	2	1			
Argentia Beach	11		10	1	1	4	1		3
Golden Days	14	2	12	7		4		3	3
Itaska Beach	8		8		3				2
Mitchell Beach	2	2	2		2				
Moonlight Bay	4		3		3				1
Sundance Beach	13		11	2	7			1	3
Fisher Home	5	2	3		2				
Norris Beach	4		4					1	
Grandview	15	1	14		3	3		1	1
Poplar Bay	12	3	9		2			1	
Viola Beach	5		5	1				2	
Crystal Springs	13	4	9		2				
Ma-Me-O Beach	9	6	1		1	1			
	123	18	99	12	28	13	1	9	14

TABLE 4b

BACKSHORE RESIDENTS - PROBLEMS WITH HIGH LEVELS

Summer Village	Number Visited	No Problems	Weeds	Less Beach	Eroded Access	Poor Drainage	Sewage	Other
Mulhurst	5	1	2		1	2		
Silver Beach	4	3		1	1			
Golden Days	6	3	1		2	1	1	
Mitchell Beach	1				1		1	
Moonlight Bay	1	1						
Mission Beach	8	6	1		2			
Sundance Beach	1			1				
Norris Beach	4	3				1		
Grandview	10	6		2		2		
Poplar Bay	4	2			1			1
Crystal Springs	5	3		1				
Ma-Me-O Beach	16	13		3				
	65	41	4	8	8	6	2	1

TABLE 5a

LAKEFRONT RESIDENTS - LENGTH OF RESIDENCE VS.
PERCEPTION OF HIGH LEVELS

Summer Village		Years at Lake 0-5	6-10	11-15	16+	Total
Silver Beach	p	1		3	4	8
	t	1		3	4	8
Argentia Beach	p			2	9	11
	t			2	9	11
Golden Days	p		5	4	3	12
	t		7	4	3	14
Itaska Beach	p			2	6	8
	t			2	6	8
Mitchell Beach	p	2				2
	t	2				2
Moonlight Bay	p	2			2	4
	t	2			2	4
Sundance Beach	p	2	1	2	6	11
	t	2	2	2	7	13
Fisher Home	p			1	2	3
	t			1	4	5
Norris Beach	p	1	2	1		4
	t	1	2	1		4
Grandview	p	1	1	1	11	14
	t	1	2	1	11	15

(continued)...

Summer Village		Years at Lake 0-5	6-10	11-15	16+	Total
Poplar Bay	p		2	2	6	10
	t		3	2	7	12
Viola Beach	p		2		3	5
	t		2		3	5
Crystal Springs	p		2	2	4	8
	t		2	5	6	13
Ma-Me-O Beach	p	1			1	2
	t	2	2	1	4	9
totals	p	10	15	20	57	102
	t	11	22	24	66	123

p = number of respondents who said they had experienced problems.

t = total who were interviewed.

TABLE 5b

BACKSHORE RESIDENTS - LENGTH OF RESIDENCE VS.
PERCEPTION OF HIGH LEVELS

			6-10	11-15	16+	Total
Mulhurst	p	2			2	4
	t	3			2	5
Silver Beach	p		0	0	1	1
	t		2	1	1	4
Golden Days	p	1	1			2
	t	2	4			6
Mitchell Beach	p		1			1
	t		1			1
Moonlight Bay	p			0		0
	t			1		1
Mission Beach	p	0		1	1	2
	t	1		3	4	8
Sundance Beach	p				1	1
	t				1	1
Norris Beach	p	0	0	0		0
	t	1	2	1		4
Grandview	p	2	1	0	1	4
	t	3	2	2	3	10
Poplar Bay	p	1	1			2
	t	2	2			4

(continued)...

		0-5	6-10	11-15	16+	Total
Crystal Springs	p	2	0		0	2
	t	2	1		2	5
Ma-Me-O Beach	p	0	0	0	4	4
	t	1	1	3	11	16
totals	p	8	4	1	10	23
	t	15	15	11	24	65

p = number of respondents who said they had experienced problems.

t = total who were interviewed.

TABLE 6a

LAKEFRONT RESIDENTS - PREFERRED ACTION

Summer Villages	Number Visited	Problems With High Levels	Preferred Action: Do Nothing	Lower the Lake 0.0-0.3m	Lower the Lake 0.3-0.4m	Lower the Lake 0.5m+	No Opinion
Silver Beach	8	8	1	6	1	0	
Argentia Beach	11	11	1	7	1	1	1
Golden Days	14	12	4	7	2	1	
Itaska Beach	8	8	0	3	3	2	
Mitchell Beach	2	2	0	1	1	0	
Moonlight Bay	4	4	1		2	1	
Sundance Beach	13	13	1	5	3	4	
Fisher Home	5	3	3	1	1	0	
Norris Beach	4	4	0	1	0	2	1
Grandview	15	14	4	7	3	1	
Poplar Bay	12	9	3	8	1	0	
Viola Beach	5	5	1	3	0	0	1
Crystal Springs	13	9	5	8	0	0	
Ma-Me-O Beach	9	3	5	4	0	0	
Total	123	105	29	61	18	12	3

1. The ranges for lowering lake levels are based on levels in July, 1981.

TABLE 6b

BACKSHORE RESIDENTS - PREFERRED ACTION

Summer Village	Number Visited	Problems With High Levels	Preferred Action				
			Do Nothing	Lower the Lake			No Opinion
				0.0-0.3m	0.3-0.4m	0.5m+	
Mulhurst	5	4	2	3	0	0	
Silver Beach	4	2	2	2	0	0	
Golden Days	6	3	3	1	0	2	
Mitchell Beach	1	1	0	0	0	1	
Moonlight Bay	1	0	0	1	0	0	
Mission Beach	8	2	5	1	1	1	
Sundance Beach	1	1	0	0	1	0	
Norris Beach	4	1	2	1	0	1	
Grandview	10	4	6	3	1	0	
Poplar Bay	4	2	1	2	1	0	
Crystal Springs	5	2	2	2	0	0	1
Ma-Me-O Beach	16	3	11	4	0	0	1
Total	65	25	34	20	4	5	2

1. The ranges for lowering the lake are based on the levels in July, 1981.

2. The questionnaire included the ranges 0.5-0.6m and 0.6m or more. Only one respondent, in Golden Days, wanted levels lowered by more than 0.6m.